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FERTILIZER USE FOR INCREASED RICE PRODUCTION

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IT is recognized that fertilizing rice fields can be one of the sure means of increasing rice production in South East Asian countries. The profitableness or otherwise of fertilizer application depends upon the degree of response obtained by fertilizer use. The attractiveness of such a response is again dependent on the relative prices of the fertilizer used and the grain produced. Mainly with the object of creating an interest and demonstrating the profitableness of a fertilizer program governments concerned might, to begin with, distribute fertilizer to farmers either free of cost or at a special subsidized rate and withdraw the help gradually when the farmers have realised the advantages and begun to use it. Subsidising the use of fertilizers is not new as even some of the more highly developed countries like Canada and Australia have adopted it as a policy. The policy to be followed will, however, have to be decided by the country concerned. With regard to rice, the deficit countries have to evaluate the cost of the possible increase in internal production by the use of fertilizers against the cost of imported rice needed to supplement the local supply. Similarly the rice surplus countries have to evaluate the cost of the increased production against the price to be obtained for the exportable surplus.

The realization of the value of fertilizer use in increasing production and the high cost of imported fertilizers have induced

some of the Asian countries to establish fertilizer manufacturing plants within the country. India, Philippines and China (Taiwan) are examples of this category. Setting up of a fertilizer plant in Pakistan is also in progress. The other countries have to depend entirely on imports for their fertilizer requirements. The prevailing market price for rice has hitherto been very favourable for exporting countries but there are already indications that such price levels cannot be long maintained and the price may have to come down. It is because of the high price for rice that the use of fertilizer, in spite of its high cost, has shown profits in most places. With a drop in the price of rice the profits from the use of fertilizers will also go down unless the price of fertilizers also goes down proportionately, which is rather unlikely at the present.

The absence of a keen demand for rice just now is by no means due to the world deficit in this commodity having been met. We have just come to the stage of production reaching the prewar level. The deficit is still there but the prevailing high price has made people in the deficit countries reduce their rice requirements and meet it by alternate cheaper cereals. Moreover, many of the rice deficit countries have experienced an exceptionally favourable rice season in 1952-53, and programs started earlier to increase internal production have also begun to contribute. The urgent need in the deficit as well as in the surplus countries is to reduce cost of production by increasing acre yields and it is to their interest to see that the price of rice does not tumble down as such a situation will remove all incentives to greater production. That countries where rice is the most important crop are alive to this situation can be seen by the action recently taken in Thailand to organise a separate department for rice so that all aspects of research and extension contributing to increased production can be tackled more effectively than before. The present position of large rice surplus in some countries and the unsatisfied needs in deficit countries is rather unique and hence the proposal by the recent FAO conference to set up a Working Party that just met in Washington to discuss the problem of disposal of surpluses of agricultural commodities.

The increased demand for rice in recent years and the prevailing attractive price for the same induced some non-Asian countries where rice was not an important crop previously to increase their rice production. The United States is a notable example of this group. The agricultural conditions in some of these countries are perhaps such that they can easily switch over from rice to some other crop the moment the price of rice drops to an uneconomic level. Such a switch over will not, however, be possible in the rice surplus countries of Asia. With the rapidly increasing population the need for more rice in Asia is almost a permanent feature. The rice growing countries in considering the present situation have to strike a balance between a high price that would make people particularly in the deficit countries reduce their rice requirements and a low price that will remove incentives for production. The use of fertilizers as a means of increasing rice production has to be considered in the above context.

The governments in developing their policy on the production, importation, pricing and use of fertilizers would require information on the quantity and nature of fertilizers that could be used and on the profitableness or otherwise of such fertilizer application to the rice grower. The available information on these points is limited in many countries, though in the last year or two some countries have undertaken large scale demonstrations of fertilizer use. The matter was fully discussed at the last meeting of the IRC Working Party on Fertilizers and it was decided that FAO should help countries to collect and compile existing data on response curves for nitrogen and phosphorus and should also assist in the planning of additional experimental work. Action has since been taken by providing scientists working in each country with standard forms showing how the data could be handled. In the meantime the existing position and experience gained on fertilizer programs in countries has been collected by sending out a special questionnaire from Bangkok. The information obtained has been summarized in the following paragraphs country by country as it was considered that such information would be of assistance to countries that may be thinking of initiating or modifying existing programs.[1] It may be mentioned that in this campaign of fertilizer use of rice, the TCA or FOA of the U.S.A. has been providing substantial help in many countries as for example in the Philippines, Thailand, China (Taiwan), India and more recently in Pakistan.

Ceylon

As a result of experiments for several years at government experimental stations followed by large scale demonstrations of cultivators' fields, three kinds of special fertilizer mixtures containing varying proportions of N, P and K are recommended by the Department of Agriculture for the low country wet zone, dry zone and the sandy tracts respectively. The quantity of the mixture recommended per acre is 120-200 lb. The fertilizers used in the mixture, sulphate of ammonia, superphosphate and muriate of potash are all imported. The stocking and sale of the fertilizer mixtures is done by the C.A.P.S. (Cooperative Agricultural Production and Sales) Societies. The fertilizer is sold to cultivators who are members of these societies at two-thirds of the cost, the other one third being a government subsidy. There are also private fertilizer firms who sell fertilizers and bone meal to individual cultivators at normal price. The quantity of fertilizers distributed through the Cooperative Societies has been steadily increasing and it is estimated that at present about 120,000 acres have been fertilized through this source using over 8,000 tons of fertilizer mixtures. These cooperative societies are sited in various parts of the country and rice farmers have not experienced any difficulty in getting their supplies and they do not have to traverse more than 5 miles.

In addition to the use of fertilizers, the Department also recommends the use of organics, green manure and cattle manure, which are increasingly adopted by progressive farmers though there are limiting factors to their extension. While the use of fertilizers is being encouraged, every effort

[1] I am thankful to the scientists of the countries concerned who were kind enough to supply me the information required.

is being made to multiply and supply pure seed of improved varieties, to extend improved cultural practices like transplanting and harrowing of broadcast fields and to supply insecticides to control pests.

China (Taiwan)

As in Japan rice production in this island bears a direct relation to the amount of chemical fertilizers used. Nearly 245,000 tons of fertilizers are used annually for rice. The Food Bureau of Taiwan controls and allocates quantities to farmers, the actual distribution, however, being made through Farmers' Associations of which there are 300 located in different townships and the rice growers do not have to traverse more than 2 miles at the most to obtain their requirements. As one of the objectives of the fertilizer program is to collect grain to supply the needs of the armed force and for rationing to civil servants, the fertilizer is issued on a barter basis for an equal quantity of paddy. If, however, for any reasons specified in the regulations the farmer has no grain to barter at the time of fertilizer issue, he can take it on loan until the harvest when it will have to be returned with an interest of 3 per cent in kind for the loan period. Some Farmers' Associations in a better financial position often extend cash loans or turn in paddy for their members to procure fertilizers allocated by the Food Bureau. Farmers are not given loans for the purchase of fertilizers although they would prefer it in view of the price of paddy being usually higher than that of an equal quantity of fertilizers. While the barter arrangement helps in the immediate recovery of dues, it also satisfies the rice needs of the administration. Often extra incentives like supply of textiles, clothing, towels, etc., also are given to encourage the barter system.

As a result of earlier work during the Japanese regime enough information has been collected on the kind and quantities of fertilizers to be applied and the present program is based on this. More experiments and demonstrations in different parts of the island are also in progress to improve the existing recommendations. For example, amonium sulphate, the chief source of nitrogen, hitherto is being partly replaced by calcium cyanamide which is manufactured locally. While nitrogen is the chief requirement, P and K are also included in the fertilizers distributed. With a recommended dose of 90-100 lb. of N per acre, 30-40 lb. of P_2O_5 and 25-30 lb. of K_2O are also included in the mixture, and the farmers have to take the whole mixture. Additional quantities of P and K fertilizerss can be bought by rice farmers at their own special request.

One special feature of fertilizing rice fields in Taiwan as in Japan is the large amount of organics like green manure, composts, pig manure, etc. which are applied in addition to fertilizers. Considerable stress is made in the extension work on the value of the organics, and experiments are in progress to determine the right kind of green manure which rice farmers can grow. Farmers are also subsidized to construct compost shelters and nights soil pits. Proper utilization of fertilizers, organic and inorganic, is considered the most important factor to increase rice production in the country.

India

The importance of the use of fertilizers to increase production of food crops is now recognised and all available information on the responses to be expected to different amounts and types of fertilizers has been collected and put together in an ICAR (Indian Council for Agricultural Research) research paper. While results available previously were from experimental stations only, additional evidence has come from experiments carried out in recent years in cultivators' fields of some of the states, Bihar, Uttar Pradesh. Madhya Pradesh and and Madras. While the available information does emphasize the necessity for more experimental work on a uniform basis all over the country, it shows, however, the possibility of undertaking a fertilizer program with expected responses from small does of 20-30 lb. of N and P_2O_5 The ICAR publication discusses the economics of fertilizer application from three angles: (i) attractiveness to the cultivator, (ii) effect on the external balance of payment and (iii) the available supply of fertilizers.

To increase rice production within the country a large scale campaign on Japanese method* of rice cultivation has been undertaken in all rice growing states of the country. It may be mentioned in this connection that greater use of fertilizers, chiefly ammonium sulphate, is the most important feature associated with the Japanese method. To encourage greater use of this fertilizer, the government has been providing certain incentives, namely, a slight reduction in the cost of the fertilizer and a grant of interest free loans to farmers to buy the fertilizer. The facilities provided vary from state to state but the information available in two of these states, Madras and Orissa, is given below.

In Madras interest free loans are issued up to a miximum of Rs. 250/- to an individual, the loan being given in kind as fertilizers. Very recently, however, the government has decided to charge interest on the loans made at 4 ½ per cent and the time allowed for repayment is usually one year. The loan is advanced on personal security and/or land cultivated. The Agriculture Department stocks the fertilizers in their godowns and issues it to the selling agents as required. The actual distribution of the fertilizer is done 60 per cent by cooperatives and 40 per cent by licensed dealers. It is said that 90 per cent of the loans usually get repaid in time. Since the collection of loans is in the hands of the Revenue Department of the government, appropriate action is taken by them to collect the loans from defaulters The number of godowns where the farmers can obtain his fertilizer requirements is, however, not too many and the farmer is often obliged to traverse more than 10-15 miles.

In Orissa, loans are issued to individual farmers on the execution of bonds to the collector of the district either on the security of land or personal security of a brother farmer. While in first year the loans were advanced free of interest, repayable at the time of harvest, i.e., 6-8 months from the time of issue, interest is now charged at 3 ¼ per cent. The period of repayment is extended up to a maximum of 3 years on

Please refer to the issue No. 8 of the News Letter

reasonable grounds, and interest is charged at $12\frac{1}{2}$ per cent beyond that period. From the information available it would appear that the loans are not repaid in time. As in Madras the absence of a sufficiently large number of distributing centres scattered within the rice area is also a difficulty working against a larger use of the fertilizer.

It may be mentioned here that the propaganda on the use of fertilizers is for its use to supplement whatever organics that may be used. The importance of growing a green manure crop is always stressed wherever facilities for cuch a practice exist. In areas where suitable improved varieties exist, supply of pure seed and use of fertilizers are taken up together.

Japan

Japan is the largest user of fertilizers for rice and so much has been written about it that it is not necessary to go into details here. It is sufficient to state that research on the use of fertilizers has been in progress for many years and the results have been utilised to make recommendations to farmers. It is, however, stated that the precise information on the optimum requirements of fertilizers and the proper relationship to be followed in using different materials is not yet available. Comprehensive field experiments at selected centres all over the country have been initiated on a national level to obtain this information. One special feature of manuring rice in Japan which is followed also in Taiwan and Korea is the insistance on a combination of organics and inorganics, the total nutrition elements applied amounting to 60-100 lb. of N, 40-60 lb. of P_2O_5 and 15-30 lb. of K_2O.

Practically all of the fertilizers used are manufactured in the country and in recent years Japan is also able to export some of them to other countries. Rice growers are well convinced of the benefits of fertilizer use and no incentives are required. They buy their requirements in the open market at prices which include profits to the manufacturing and distributing agencies. Since rice is under government control, rice growers are bound to sell their surplus to the government. Under this system loans requisite for the purchase of farm production materials are provided to farmers on the security of payment for the rice to be delivered. Such loans are made through local agricultural cooperatives which also arrange for the collection. Due to the existence of a large number of cooperatives, the rice farmers do not have to traverse more than a mile at the most either to receive the fertilizer or to hand over the surplus rice. The government does not exercise any control over fertilizer distribution, except to see that there is enough supply to meet the demand. The use of fertilizers for rice having become an established practice with farmers, a general fertiliser extension program has little importance in Japan, though improvements in methods of application and recommending particular combinations of fertilizers for special conditions do receive attention.

Malaya

Because of large variations in soil and rice growing conditions in Malaya large experiments with fertilizers have been conducted in different areas, and it can be said sufficient data have been accumulated to permit making firm recommendations on

fertilizer practice in North East coast region (Kelantan and Trangganu). Investigations are also in progress elsewhere but they are well advanced in the North West region (Kedah-Perlis) where the heaviest yielding rice lands of the Federation are situated. For the North East area 200 lb. of a special fertilizer mixture based on a departmental formula containing 23 lb. N, 20 lb. P_2O_5 and 25 lb. K_2O is recommended and the sale of the fertilizer is in the hands of a special agency which has controlled depots in the area. While the price charged by the agency include their normal profit, government pays a subsidy of $6 (Singapore) per 100 lb. of the fertilizer. The rice fields are usually remote from roads and distribution centres. Half the transport charges are met by R.I.D.A. (Rural and Industrial Development Authority) who arrange for the supply at nearest points on the road side from where the farmers take it home on the back of their bicycles. The average maximum distance of a distribution centre from the village can vary from 7 to 10 miles. It is stated that the existing incentives have not created a widespread demand for the fertilizer but there are no proposals either to widen or reduce the scope of the existing incentives.

In the Kedah-Perlis area there is a traditional use of phosphatic fertilizers almost solely in the shape of bat guano and sulphate of ammonia. Immediately after the war, the government used to sell bat guano to rice growers on credit but this has since been stopped as large sums were still outstanding with the growers. This area is well served by roads and farmers can get delivery of fertilizers within 2-3 miles of their farms. It is not proposed to offer any incentives in this area. Experimental results available so far show that a useful fertilizer application for this area could be 100 lb. of P_2O_5 as bat guano and 30 lb. N as sulphate of ammonia.

Among various programs to improve rice production, the importance of individual programs varies with the areas concerned. With efficient water control, the use of fertilizers offers a better scope to increase production in North West and North East regions than any other program. In the equatorial region of deep bog-soils the use of improved seed is considered more important than the use of fertilizers. Similary in small areas of Perak and Malacca, the control of pests and diseases is considered relatively more important than other programs. In the fertilizer programs attention is given either to all the three nutrients N, P and K or N and P, chiefly as inorganic fertilizers. Experimental work on organic manures is still in progress. Green manure has not given reliable results while other organic manures are not normally available in quantity. Fertilizers are all imported and the use of locally available bat guano is encouraged and the best grades of this are subject to export controls within the Federation.

Pakistan

Experiments on the use of fertilizers have hitherto been confined to a few research stations and, although useful information has been obtained such information is not considered enough to make firm recommendations to rice growers in different areas. More experiments supplemented by

large scale demonstrations in cultivators' fields would be necessary to estimate the response that may be expected from the use of fertilizers. This has just started receiving attention and TCA of U.S.A. is providing the necessary help. In 1953 a large scale demonstration of the application of ammonium sulphate to rice in one of the rice districts of Punjab was undertaken. The fertilizer was applied over an area of 11,000 acres, the culivators getting it almost free, paying only for transport, and it is said that the compaign was a success. Ammonium sulphate applied at 150 lb. per acre (30 lb. N) has produced an average increased yield of 400 lb. grain per acre. It is expected that more demonstrations of this kind will be undertaken in other rice areas of the country in 1954.

The Philippines

Information on the correct use of fertilizers in different areas of the country is still limited but recommendations now made depend upon this limited information. More detailed experiments are in progress, and in addition, during the last two seasons, thousands of demonstration cum experimental plots have been laid in cultivators' fields and these are providing very useful data. The treatments included in the demonstration plots deal with all the three nutrients, N alone, $N + P_2O_5$ and $N + P_2O_5 + K_2O$ to supply 26 lb. of each per acre. There also were multiples of the three nutrients included in the treatments. The examination of the data has shown that for over 90 per cent of the plots, the responses for N alone and for the complete fertilizer were sufficient to show a substantial profit to the farmer, though it was somewhat smaller for the complete fertilizer than for N alone

The fertilizers used at present are all imported and the mixed fertilizers are compounded before shipment to the country. A plant to manufacture 50,000 tons of ammonium sulphate annually has been built, and has just come into production. Most of the fertilizer distribution is under the control of a special Fertilizer Administration Section of the Department of Agriculture and Natural Resources. There are also private importers dealing with fertilizers and also another government agency but the latter will stop functioning very soon. Fertilizers handled by the Fertilizer Administration are sold at cost price (imported price plus all handling expenses) when sold on loan basis but at a 20 per cent discount for cash. The Administration grants loans to farmers and no interest is charged if cleared at harvest time. Return of the loan in kind is also accepted at price of grain fixed by the government. The Administration has field agents spread all over the country who attend to distribution of fertilizers and collection of loans but it is said loan repayment has not been very satisfactory. The government is also encouraging cooperatives to deal with the problem of fertilizer distribution but their number and coverage are small at the present moment. The Adminsitration arranges for the distribution of fertilizers at all township and also in villages accessible to motor transport and the distribution centre is never more than a mile or two distant in any case.

While the existing incentives for farmers are considered sufficient, there is a proposal even to eliminate the subsidy or

20% discount soon. The Department is encouraging fermers to use organics in addition to chemical fertilizers but no appreciable progress has yet been made. Under the existing conditions in the Philippines a fertilizer extension project is considered the most important factor for increasing production although other possibilities also receive attention.

Thailand

Sufficient information on the kind and amount of fertilizers to be used in different parts of Thailand is lacking. Experiments are, however, in progress in different regions of Thailand to obtain this information. There is, however, an indication already available that phosphorus is even more important than nitrogen for Thailand soils, and recommendation made to farmers is always a combination of N & P_2O_5 either in equal quantities of each or more of the latter than the former. Potassium is also recommended sparingly for special areas. The compound fertilizer, ammophos (16-20) has always given satisfactory results but this fertilizer is, however, not available in the market in quantities. Since under swamp conditions ground rock phosphate has been found to be as good as superphosphate, more use is now being made of the former as a supplier of phosphorus. All fertilizers used in Thailand are imported. Import of fertilizers, making of the appropriate mixtures, transporting them into rural areas and the actual sale to farmers are all under the control of the Agriculture Department. The incentives given to the rice growers to use fertilizers is the supply of the same at half the cost and delivery on the spot without charging for transportation. While the farmers do not get any loans towards the purchase of fertilizers, if they are members of a cooperative society they pay cash only for half the subsidized price on delivery and the other half after the crop is harvested, the cooperatives standing guarantee in the meantime.

Until reliable results become available from the experiments in progress, the propaganda on the use of fertilizers will be limited in scope. In 1953 fertilizers were used only on 40,000 acres and the target aimed at 1,200,000 acres or about 10 per cent of the total rice area by 1960. The fertilizer distribution centres are not too many and the maximum distance of any distribution centre from a village is perhaps 12 to 15 miles.

The only organic manure available in limited quantities is cattle manure and the farmers do use it. There are no programs to increase the organic manure to supplement chemical fertilizers. Under Thailand conditions a fertilizer program is considered next in importance only to the supply of pure seed.

MECHANIZATION FOR THE SMALL FARMER

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The mechanization of agriculture has been a controversial subject for a long time. It has had strong advocates and equally strong opponents. The term has been used with various connotations of meaning and part of the controversy has been due to lack of understanding of what was to be accomplished by mechanization or what exactly was meant by the term. Our discussion will be facilitated if we agree on what we mean by terms.

The term "mechanization" in this paper will be used to mean the application of mechanical power to agricultural production. It is distinct from the application of improved tools and implements but usually or always involves the use of improved implements and tools for its effective use. Human or animal power may be used with improved implements; mechanization involves the use of some form of mechanically produced power such as steam, internal combustion engine or electricity.

The broad objective of any change in method or equipment with which we do our work is of course "improvement". Our idea of what constitutes improvement may change from time to time and from place to place. In general, in the past the over-riding need has been for an increase in production. We have rarely ever had all we wanted of anything for long and there has usually been a shortage of some kinds of things even though we may have had enough of a few things. Therefore our idea of improvement in the past has usually been something which would enable us to increase the quantity of output or production. Another criterion of improvement has been reduction in cost of production, which is a way of saying that production is increased in terms of effort put into it, in relation to the effort required for other purposes. A third criterion of improvement which has had comparatively little attention focused on it is the reduction of human drudgery, the reduction in the use of human effort involved in production. Farming has always been recognised as hard work; it is only recently that the idea has become prevalent that either the time involved or the effort required could be reduced.

Most of the above applies to both industrial production and to farming. Let us from here on discuss more particularly the problems of agriculture. We can restate the above to say that the objectives of mechanising agricultural production would be increased production at reduced cost in terms of money and at a reduction in the time and effort required to get the production. The relative importance of increase in production versus reduction in effort and cost will vary from time to time and place to place. Some times we may be willing to go on expanding the same effort if we can only increase our output. In other cases the other extreme will be that we are willing to continue with the same or very modest increase in output if only the

intolerable burden of effort can be eased. All stages in between may occur.

"Increase in production" may be sharply differentiated into two phases, (1) increase in production per worker and (2) increase in production per acre. The two do not necessarily go together. In some cases we may get very large increases per worker by accepting methods which involved cultivating large increased areas at a reduced yield per acre. In other cases very large increases per acre may be secured by methods which result in much less production per worker, that is by the expenditure of much more labour on each acre cultivated. Many factors enter into any decision as to which is desirable or possible in any particular case.

More specifically we may say that the objective of mechanization—the application of mechanical power to agricultural production—has primarily the objective of increasing the area which one person can control or use effectively. With human power alone, only the simple hand tools are possible, the hoe, the spade, the rake, the sickle and other simple tools. With these, a man can cultivate usually only a fraction of an acre. With the use of animal power, the area controlled varies widely depending upon the animals used and the implements utilised. At the bottom of the range is the 5 to 10 acres which can be effectively cultivated to annually sown crops in India with the simple wooden plow. At the other end would be the 75 acres or more possible with horses and improved large implements. The area increases as the animal power is supplemented increasingly by the use of mechanical power for specialised operations such as crop processing and harvesting. With mechanical power the area which one man can control goes on up to very high figures of several hundred acres. In general both gross and net income of the individual will vary directly with the area cultivated.

These figures presuppose, of course, the availability of land. In most of the crowded countries of the East, holdings are small because of the high ratio of people to land available. Most of the good land has been brought under cultivation. Only marginal land is still available for reclamation. While in some cases the area in acres is large, and even the percentage is large, the potential increase in area per holding is small. In India for instance, there are some millions of acres of "culturable wastes" about 40% as much in area as is now cultivated. However, if this were all brought under cultivation and if holdings could be redistributed equally, the common size of holding of about 5 acres would only be increased to 7 acres, not a very large holding.

Industrialization is often recommended as a means of taking large numbers of people out of agriculture, thereby securing large areas per farm so as to allow mechanization. Industrial development is undoubtedly desirable and should be carried out as far as possible. However, we must remember that industrialization requires both resources and capital. The latter especially is in very short supply and the one source from which it can come is from the savings of the people. The margin for saving is very slender now and can be increased immediately and largely only by reducing the already low standard of living. However, even if we assume abundant

natural resources, industrial development even to the standard of the Western countries does not make large holdings available. If we assume that in most Eastern countries about 75% of the population is engaged in agriculture and 25% is engaged in non-agricultural employment and the professions, finding industrial employment for people on the same basis as in the West would involve 2 out 3 now engaged in agriculture leaving agriculture for industrial employment. If all leaving agriculture for industrial employment had average holdings, this would increase the remaining holdings to 3 times their present size or from 5 acres to 15 acres in India. This ignores two difficult problems, the presence of a large number of landless agricutural laborers and the increasing population. The fact that industrial employment can increase only slowly makes it unlikely that the industrial development of the crowded Eastern countries can provide employment for the increase in population. It does not seem likely that at best it can do more than drain off the landless laborer population. It seems very unlikely that it can in the foreseeable future lead to sufficient combining of holdings to make large holdings.

It appears therefore that the continuance of small holding agriculture is inevitable or rather that we must accept the continuance of a high ratio of people to land in these countries. Of course the combination of a large number of holdings into one unit without displacing people from the land is technically possible but it requires organization of society on new lines and it does not achieve the objective of mechanization, that of enabling a few people to cultivate a large area, unless of course we work out a social organization in which a small proportion of the total people supported do the work. On the basis of present experience, it seems to me that, in the crowded countries of the East, the total of human happiness will be greater if the land continues to be divided into small holdings than if it is combined into large units with the accompanying problems of social organization.

Problems of Mechanization of Small Holdings

Let us explore the problems, the difficulties, of mechanizing small holdings. There are two phases of mechanization: (1) the mechanization of field operations, which is what most people think of when using the term; (2) the mechanization of "barnyard" operations, those operations which can be done at the village site or at some central place and which do not involve taking large machines to the fields.

The mechanization of field operations, the plowing and harrowing, seeding and interculture, is very difficult on small holdings. We may dismiss as probably solveable the difficulty of capital and of lack of skill in operation of such equipment. The necessary skill can certainly be taught and learned. Probably the necessary capital can eventually be acquired, painful and slow though the process will be. These can be only retardents, not factors that would prevent mechanization. The availability of metals seems more difficult, though probably eventually solveable. Certainly there is a world wide shortage of iron still now and any large increase in use for one purpose must inevitably reduce the amount used for other purposes, at least for the

time being. Some substitution of other metals may be possible. Capital is certainly a retardent. In India at present with animal power available, the capital required to mechanise a small holding is 3 to 5 times as much as is required to equip the same holding with animals and adequate suitable improved implements.

The one insuperable obstacle seems to be the land required to be put out of cultivation. On large farms, mechanization is thought of as ***releasing extra land*** for food production. It is often stated that each horse in America requires 3 acres of land for producing its feed and fodder. In India, animals used on farms are fed almost 100% by byproducts, straws, stovers, oilcake, weeds and grass taken from the fields in normal cultural operations. It is true that this feed could be fed to other animals. It is also true that if the animals to which it is fed are cows, and pair of them can do all the work required on a 5 to 10 acre farm and still give all the milk of which they are genetically capable. If it is fed to meat producing animals, the value of the animals produced must pay for the high priced liquid fuel to replace them as sources of power. There must also be a market for the meat.

It may be suggested that these organic materials could be composted into manure. Passing them through the cow may add as much as composting does to their manurial value or lose no more than the normal loss of bulk and weight in the composting process. Labour involved in gathering and feeding may be no more than the labour involving in gathering and composting. The compost has to be spread on the field as does the manure produced. On the whole, it seems that the feeding of these byproducts involves little or no cost in either labor not otherwise required or material if the manure is carefully preserved. In any case no appreciable saving of land would occur as practically none is now devoted exclusively to feed production.

The difficulty with land needed is that of getting the mechanised implements to and from the fields. At present the fields are separated by narrow paths or small embankments which take no more room than fences would take. The animals can walk to and from the fields single file and the implements are carried. Pressure on the land has forced the concentration of houses in most cases into villages. Very little land is now required for roads. For mechanised agriculture it would be necessary to have access to every field by road. Even smaller units would be so costly as to make necessary their use on more than one holding. In some cases, it may be possible to cross an unoccupied field but in most cases some sort of road or track is essential. Mechanised units obviously cannot, even the small so called "garden" tractors cannot, go along the existing footpaths. This problem exists whether the holding is consolidated into one compact block or is in scattered fields, though the scattered fields arrangement may intensify it.

The mechanization of "barnyard" operations seems, by contrast, much easier and more desirable. Many of these operations can be mechanised without any extensive change of the social organization, with no or infinitismal demand on the land under cultivation and with a minimum of

material and capital. An example of the sort of mechanization to which I refer is the small engine driven stone burr grist mill in India. Up to about 40 years ago, most of the bread grains used in India were ground by hand in small stone burr mills operated daily by the women folk in the home. Now most of the flour and meal is ground by larger stone burr mills driven by oil engines or, where power is available by electric motors, a common size being about 10 hp. People bring cleaned grain enough for a week or a month supply, have it ground, paying a few small coins and go away. The mill is located in a central village occupies a small space only and has lifted a great burden of drudgery off the shoulders of the women folk. The investment of capital per family served is moderate because it is spread over so many families. The engine is usually a Diesel type, may be imported or made in the country, and is economical in operation. It runs only when there is enough work to do, it is usually well loaded and the cost per unit of work done is quite small. The mill is usually locally made, of stone and wood with only a a minimum of metal required. The demand on scarce resources is small. It provides occupation for a few workers for construction and operation, performs a useful service but does not disrupt any other employment. The time and the effort of the women folk is released for other work in the home or in some cases for work in the fields or other employment. Since the mill is owned by individual in most cases, there is no necessity for any complicated social organization, no society which people may be forced to join in order to get supposed benefits. The benefits are obvious to the customer, who can take them or leave them at his discretion as their provision does not depend on serving of the whole population of an area.

The same pattern can be applied to quite a variety of operations. Some of them can be carried out, as is the grist mill, in one central location, the work being brought to the mill. Others can best be done by a portable unit moved to the work but operating in the village site. Already some of the grist mills are adding small chaff cutters to their installation, often thereby legthening the time their engines can be operated. At present cattle are fed a large part of the year on fodder, grass or stovers which are chopped up finely by hand, thus reducing the effort the animal needs to put into eating and digesting the feed and improving the utilization by the animals of the relatively poor feeds available. This hand chaffing may take hours of work, drudgery which often results in maimed hands, and time consuming work which often competes with urgent field work for the farmers' time. If a small installation is available, people are already finding that it saves time and effort to take a few bundles to be chaffed and to bring back the chopped fodder. In case of dry fodders, daily and frequent chaffing is not necessary, a whole crop can be chaffed when the cutter is available. In spite of the large number of cattle and the availability of suitable material, silage making has made very little progress in India, mainly because of lack of equipment to quickly chaff the fodder before storing it. The chaffing of green fodders for silage and the chaffing of dry stovers for feeding seems an eminently

suitable operation for mechanization, an operation which can be mechanised with a minimum of investment, a minimum use of scarce metal resources and with a minimum of disruption of the existing social organization, and with a large dividend of relief from drudgery, a release of productive time and energy for more profitable occupation on the farm. Already the hand chaff cutter is displacing the hand chopper and wherever power driven chaff cutters have been installed, mostly in connection with grist mills, they are increasingly popular.

Other operations of the same sort which can be readily mechanised are pumping for irrigation, threshing of grain, crushing of sugar cane for production of crude sugar. Cane crushing and threshing are usually carried out at or near the village site, often the whole village using a common threshing floor for threshing. These operations are all suitable for mechanical power driven equipment, they can be done for a number of customers and payment can be made quite easily on the basis of work done. They can all be done by equipment which can be readily moved from place to place. In some cases there is still need for adaptation of the machines to the work to be done; there are no really satisfactory machines for the threshing operation under Eastern tropical conditions but it should not be difficult to evolve such equipment. In fact such adaptation is still necessary for all the operations suggested for mechanization but a start toward mechanization need not be delayed until such adaptation is completed. We can start with what we now have. Adaptation can go on with experience as a guide.

To say that we are opposed to mechanization of field operations at this stage is not to accept the present methods. The effectiveness of the presently available human and animal power can be increased many times by the use of better tools and implements, tools and implements which can be introduced into the present pattern of cultivation without drastic changes in social organization and with a minimum investment of capital and a minimum demand on scarce metals supplied. Doubtless such changes will start chain reactions and one end result may well be more favourable conditions for further mechanization. If this comes about naturally, we need not oppose it. Certainly we should immediately strive in every way possible to improve the implements and tools and the application of the animal power now available to reduce human drudgery in every way possible and to increase the production of food, feed and fibre to the greatest extent possible. I believe that this can be done most rapidly and effectively at this stage by the widespread increase in the use of improved implements and tools for hand and animal operation by concentration of efforts toward mechanization on the mechanization of the barn-yard operations, those operations done at the farm or village site rather than in the field.

PRELIMINARY NOTES ON PHYSIOLOGICAL DISEASES OF RICE IN MALAYA

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General

The first report of a rice disease which did not appear to be caused by any insect, fungus or other organism was published in 1935 (Reports of the Research, Economic and Agricultural Education Branches, Department of Agriculture, S. S. & F. M. S. for 1934). The disease was called "penyakit merah." A very short reference to the disease was also made in 1940 (Notes on Plant Diseases in 1939 by A. Thompson: Malayan Agricultural Journal *28*, 402). Since 1946 numerous cases of "penyakit merah" from various parts of Malaya have been observed and examined.

The commonest name given to this type of non-parasitic disease is "penyakit merah" (red disease), the name referring to the reddish discolouration often seen on the leaves. Other names in less common use are "benah darah" (blood-coloured blight), "penyakit rendah" (stunting disease) and "penyakit kisar" (reversal of growth disease). These terms may sometimes also be applied to diseases caused by fungi (e.g. *Helminthosporium oryzae, Rhizoctonia solani*). or to cases of attack by insects (e.g. stem borers). In general, however, the names are reserved for apparently non-parasitic diseases.

Symptoms

An examination of numerous specimens from different parts of the country indicates that three more or less distinct types of symptoms can be distinguished. In all cases the name "penyakit merah" is applied although, as described below, the name is not always justified, in that reddening of the leaves does not invariably occur. In such cases the names "penyakit rendah" or "penyakit kisar" would be more appropriate.

In all types of the disease symptoms only appear some time after transplanting. The feature common to all cases of "penyakit merah" is a retardation of growth, affected plants ceasing to increase in height. The outer leaves also tend to dry up from the tips and die prematurely so that the number of leaves is also reduced. Affected plants may recover after a time and produce some grain, or they may remain alive but stunted, producing no grain or they may die off completely.

The three types of "penyakit merah" are described in more detail below:

Type A. The general colour of the leaves is a normal healthy green but as the disease develops the tips of the older leaves show very marked reddening. Between the normal green part of the leaf and the part which is completely red in colour there is a zone in which reddish or purplish speckling occurs. A typical tiller examined had the following appearance:

Youngest leaf - normal green colour.

2nd youngest leaf - sheath and lower half of leaf was of a normal green colour. About half-way up the leaf blade there

was some dark purple speckling, more marked towards the edge of the leaf than in the centre. The tip of the leaf had a rusty red tinge, merging into dark purple along the edges.

3rd youngest leaf-symptoms were similar to those in the 2nd youngest leaf but were more marked, the rusty red colouration extenting half-way down the leaf. The tip of the leaf was dried out, brown and dead.

4th youngest leaf-the reddish discolouration extended rather more than half-way down the leaf blade while the upper third of the leaf blade was brown and dead.

5th youngest leaf-the upper three-quarters of the leaf blade was dried up and dead. The rest of the leaf blade was orange-yellow in colour and drying out, only the midrib still being green. The sheath had the normal green colour.

6th, 7th and 8th leaves—both leaf sheat and blade were completely dead.

The root system of plants affected by this type of disease may be fairly extensive but the majority of the roots appear to be dead or dying and healthy roots are very few.

Type B. As in type A the younger leaves are of a normal green colour. The first symptom of the disease to occur is the appearance of small, irregular, rather diffuse yellow areas towards the tips of the leaves. On older leaves these yellow areas spread and coalesce so that the whole leaf tip becomes uniformly yellow. Soon after this happens the leaf tip becomes brown and dries out. This browning and drying out affects the edge of the leaf first so that the edge of the leaf may be dead for a considerable distance below the tip while the tissues in the centre of the leaf remain green and alive. As the leaf blade dries out it curls upwards and inwards. Withered tissues are usually light brown or may be pale orange in colour. There is no reddening of the leaves. Ultimately the whole leaf blade and finally the sheath dries up and dies. A typical tiller had the following appearance:

Youngest leaf — normal green colour.

2nd youngest leaf — sheath and most of blades were of a normal green colour, with a little ill-definined yellow mottling towards the tip, which was brown and drying out.

3rd youngest leaf — the upper third of the leaf blade was brown and dead; below the dead area was a yellow zone, while the lower half of the leaf blade was healthy.

4th youngest leaf — almost half of the leaf blade was dead. For the rest of the length of the blade the edge was dead: within was a yellow zone, while the midrib was green. The sheath was of a normal green colour.

5th youngest leaf—the whole leaf, including the sheath, was dead.

6th youngest leaf — only the rotten base of the sheath remained.

The root system of plants affected by this type of disease tends to be scanty and most of the roots are brown and rotten. New roots are produced above the older roots but do not appear to remain functional for long.

Type C. This is something similar in general characteristics to type B, there being

extensive premature dying of the leaves, preceded by chlorosis. No red colouration developed. The main difference is in the colour of the young leaves: these have a dark, blue-green tinge unlike the normal green of healthy plants. The appearance of a typical tiller examined was:

Youngest leaf- healthy.

2nd youngest leaf—the extreme tip was beginning to dry out: below that there was slight yellowing of the edges of the leaf for a short distance; the rest of the leaf had a dark, bluish-green colour.

3rd youngest leaf—the tip was dead and brown. The rest of the upper half of the blade was drying out and was light orange in colour. The lower half of the blade was dark bluish-green.

4th youngest leaf- the blade was completely dead, grey and dried up and was curled upwards. The top of the leaf sheath was beginning to die off.

5th youngest leaf- completely rotten and dead.

The root system in type C plants may be fairly extensive but the number of healthy roots is low.

Occurrence

"Penyakit merah" occurs in widely dispersed areas in many parts of Malaya. The disease does not affect large areas but occurs in small scattered patches. It tends to reappear in the same place in successive years but the extent and severity of the disease varies greatly from year to year and quite commonly an area which is badly affected one season may be free from the disease the next. After a period the disease may reappear.

From information so far collected it appears that the three different types of disease tend to occur in different parts of the country, although there is no clear-cut distinction. For example, type A has been found commonly in Malacca, Negri Sembilan and Perak, type B in Kedah, Penang and Pahang and type C in Kelantan.

Cause

Little is known as yet regarding the cause of "penyakit merah" but it is almost certain that the disease can be caused by different factors. Work so far carried out, including the growing of rice in nutrient solutions and the application of nutrients to affected plants in the field suggest that a deficiency of one or other of the major nutrients may, at least in some cases, be the cause of the trouble. Work in this direction is continuing.

STUDIES ON THE BLUE-GREEN ALGAE IN JAPAN

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The fist studies of the blue-green algae in Japan by Mr. M. Shiori appeared in 1942. Since 1951, Okuda of Kyoto University as coordinator, S. Nishigaki, O. Ishizawa, National Institute of Agricultural Sciences, C. Konishi, Hokuriku Regional Agricultural Station, T. Hirano, Sikoku Regional Agricultural Station, Watanabe,

Pharamaceutical Research Institute of Tokyo University, and members of several prefectural agricultural experiment stations have been engaged in the study. The following is a brief outline of the results obtained.

M. Shiori and S. Nishigaki reported that when paddy soil was kept in an Erlenmeyer flask under water-logged conditions, blue-green algae such as *Nostoc* and *Oscillaria* would propagate in several days. When these organisms propagate profusely, soil nitrogen will be greatly increased. The propagation of the blue-green algae can be further accelerated by adding lime and phosphates and in such cases the nitrogen fixed may amount to about 22.5 kgs. per hectare. They explained that when nitrogen was being lost in the superficial oxidative layer due to oxidation and leaching, nitrogen fixation occured under favourable conditions; and that the nitrogen component of the algae, if it was put into the reductive layer of soil by such practices as weeding and others, would be converted into ammonia. T. Hirano disclosed that phosphatic fertilizers applied to the paddy field would enrich the soil in respect of nitrogen and explained that this was due to the profuse propagation of algae and other aquatic plants which would enrich the soil with carbon and nitrogen.

S. Mitsui and T. Harada confirmed that the application of "quick" or "slaked" lime would accelerate the bacterial decomposition of the organic matter in the paddy soil and might replace nitrogenous fertilizers to some extent. Such lime effect can be had without the danger of diminishing soil fertility if the amount of lime applied is about one and half tons per hectare. The reason why the soil was not impoverished with successive lime applications was the fact that by applying lime the propagation of blue-green algae was accelerated and nitrogen was sufficiently fixed to compensate the loss caused by lime applications.

Since 1941 Watanabe isolated some ten species of blue-green algae from more than six hundred soil samples collected from southwestern tropical areas. *Tolypothrix tenuis* from Borneo, *Calothrix brevissima* from Palau island and *Anabaenopsis* spp. from Sumatra were found to be powerful nitrogen fixers. These three species fixed 5.2 mg., 3.4 mg. and 2.1 mg. of nitrogen respectively at 25 degrees C when exposed to the sun for two months in 100 cc. of nitrogen free culture solutions. Okuda studied the distribution of the blue-green algae in Japanese paddy fields. He reported that, with a few exceptions, all the paddy soils he examined were inhabited by the blue-green algae. Further experiments were carried out on the relation between the soil conditions and the algae propagation, indicating that the soil reaction and the available phosphorus content were the most important factors affecting the algae propagation.

S. Nishigaki in cooperation with Watanabe made a pot experiment with the above-mentioned three species of blue-green algae isolated by the latter. He concluded that *Tolypothrix* had a definite positive effect on rice plants while no such positive effect was found in the case of *Anabaenopsis*. It was found that *Tolypothrix* fixed 22.5 kgs. of nitrogen per hectare and the rice plants absorbed about 4.8 kgs. of nitrogen more than the control. The considerable amount of nitrogen which was

left unabsorbed in the soil was found to be absorbed the next year.

Okuda, T. Hirano and C. Konishi also reported on the possibility of inoculating the field with algae, but the exclusion from the field of *Daphnia* and *Viviparus* which devour the algae is essential, not to mention the application of lime and phosphorus. For killing these animals, a new insecticide, "parathion", is very effective when applied to the irrigation water.

Hirano Konishi reported that a 15 to 20 per cent yield increase was obtained with the algae inoculation. At present similar inoculation experiments are in progress in several prefectural agricultural experiment stations. These experiments aim at increasing yield by the propagation of powerful nitrogen fixers. In the meantime, it is also possible to increase the soil nitrogen content by strengthening the indigenous blue-green algae. In Japan the practice has been to apply lime even when the correcting of soil acidity is not necessary but the beneficial effect may be explained by the strengthening of the indigenous blue-green algae.

It is suggested that in the region of South East Asia where commercial fertilizers are not readily available and too costly, inoculation unith the powerful nitrogen fixing algae or the strengthening of the indigenous algae may be a means of getting a cheap supply of nitrogen.

Lastly, it should be pointed out that the beneficial effect of the algae seems to disappear when a great deal of nitrogenous fertilizers is applied, as is usually the case in Japan.

SPRING PADDY IN EAST PAKISTAN

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The area under spring paddy represents 4% of the total area of 19.6 million acres under paddy in East Pakistan. It is a marshy land where no other crops can be grown successfully. The rice crop is grown from November to April. Under favourable conditions, it can yield as high as 3,200 lbs. of paddy per acre. The following is a brief description of its cultivation as practised at the Deep Water Paddy Research Station, Habiganj, East Pakistan.

Nursery: Nursery beds are selected from a comparatively high level of land where flood water recedes by the end of October or beginning of November. The soils of such land are generally clayey in nature. It has been found profitable to break open the seed bed in May-June and to keep it submerged during the monsoon time. This stimulates a vigorus growth of the seedlings in the season following. The nursery is cleared of aquatic vegetation in October after which it is made ready for sowing by the middle of November. The

seed bed is manured with cowdung at the rate of 60 lbs. N per acre. Before sowing, the nursery is laid out into small beds with facilities for drainage and irrigation. Seeds are sown thick at the rate of 560 lbs. per acre. When seedlings get a stand, nursery is irrigated once and a second irrigation is given about fortnight later. The practice of thorough puddling of nurseries, early irrigation and thick-sowing helps to keep down weeds and hence the need of weeding seed beds is not felt. Seedlings are ready for transplanting within five weeks after sowing.

Field Preparation: It always pays to plow spring paddy fields after harvest in May-June so as to facilitate the subsequent preparation of the land. As the land remains submerged from May to December, aquatic plants grow abundantly. They are cleared off in October-November in breast-deep water. A bullock-drawn light wooden plough is used. If the land is plowed in summer, one more plowing will be necessary before sowing. Otherwise the land will be plowed twice.

Transplanting: The best transplanting time is from late December to mid-January. After that there will be a fall in the yield. Seedlings should be carefully uprooted without damaging their roots. In general, for early transplanting, 2-3 seedlings per hole are planted 9" apart; but for late transplanting, spacing should be reduced to 6" and the number of seedlings should be increased to 4-6 per hole.

Weeding: Hand picking of weeds is the only form of weeding in spring paddy fields. Aquatic weeds are very persistent and require repeated uprootings. During the process of uprooting, the roots of spring paddy plants get the benefit of interculture. This is the only form of interculture available to the spring paddy and the success of the crop often depends on this weeding.

Irrigation: Spring paddy has to be irrigated from January to mid-March after which rains can meet the requirement.

Manuring: Experiments conducted with spring paddy at the Deep Water Paddy Research Station, Habiganj, have failed to record any manurial response in favour of bulky organic manures like water hyacinth (raw & rotten), cowdung, mustard cake and bonemeal. Possibly leaf, root and other residues of aquatic vegetation annually incorporated with the soil during plowing can meet the requirement of organic manures and no additional supply of such manure is necessary for the crop.

The application of ammonium sulphate in spring paddy has, however, been profitably responded to. The land on high levels dries up within a month of transplanting when ammonium sulphate can be spread broadcast on wet fields. But due to the difficulty of running any bullock-drawn tillage implement at this stage, nothing can be done to put ammonium sulphate 2"-3" below the soil-surface. The following are the results obtained with ammonium sulphate broadcast on spring paddy on the 30th day after transplanting.

	Yield (lbs/acre)		Increase in lbs. per acre	
	Grain	Straw	Grain	Straw
Control	2,975	8,147		
Amm. Sulphate 100 lbs/acre	3,293	9,973	318	1,826
Amm. Sulphate 200 lbs/acre	3,151	11,061	176	2,914
Amm. Sulphate 300 lbs/acre	3,156	10,536	186	2,389

Taking grain and straw together, the application of ammonium sulphate at the rate of 100 lbs. per acre on the 30th day after transplanting comes out to be the most profitable and is recommended for spring paddy in East Pakistan.

Harvesting: Spring paddy will be ready for harvesting 30-35 days after flowering. Harvesting has to be completed before the monsoon season sets in.

Conclusion: Though spring paddy is planted in winter, its growth and tillering start vigorously with a slight rise of temperature in the second half of February. Hence it can be tried on any marshy land in a moderately warm climate. This note is released with a view to acquainting workers in the other parts of the world with the cultivation of this crop in its homeland so that they may try out spring paddy under suitable conditions.

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